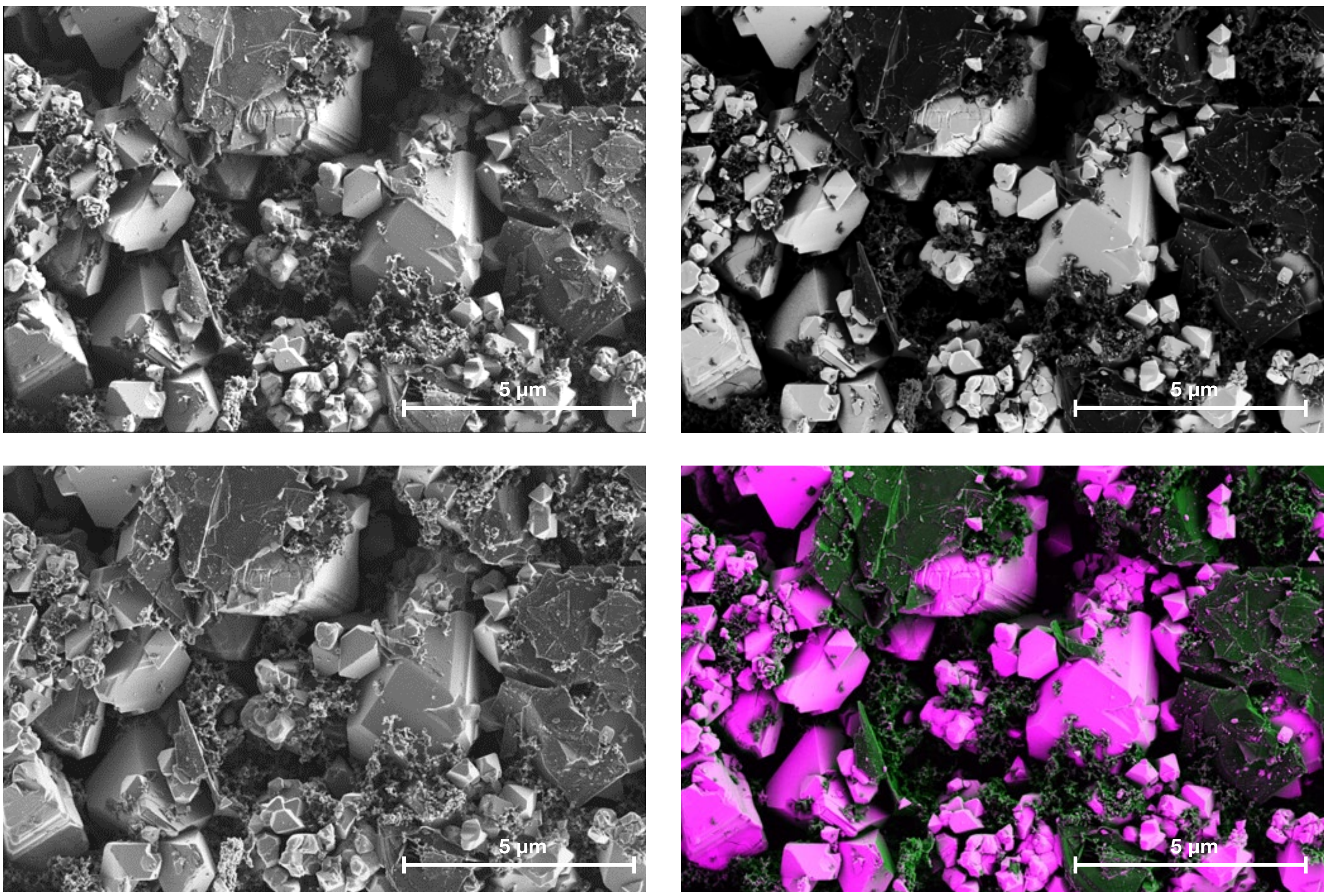
Battery Materials Analysis

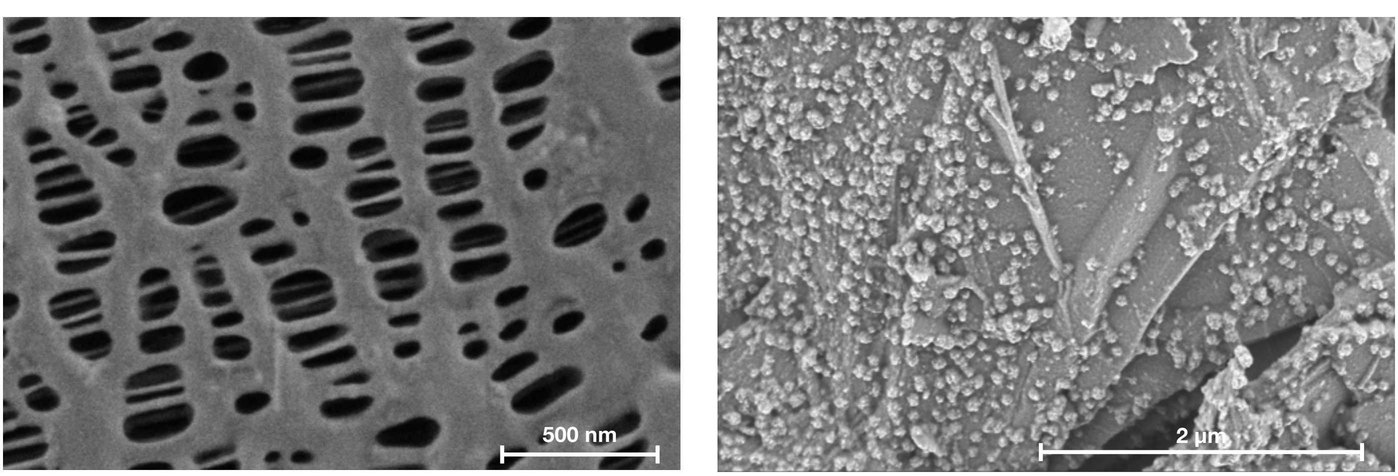
High resolution imaging and analysis in 2D and 3D for structural characterization, transport modeling and failure analysis.

High Resolution Imaging with Apreo SEM

Explore your sample with the most versatile detector setup, low voltage capabilities and analytical solutions.



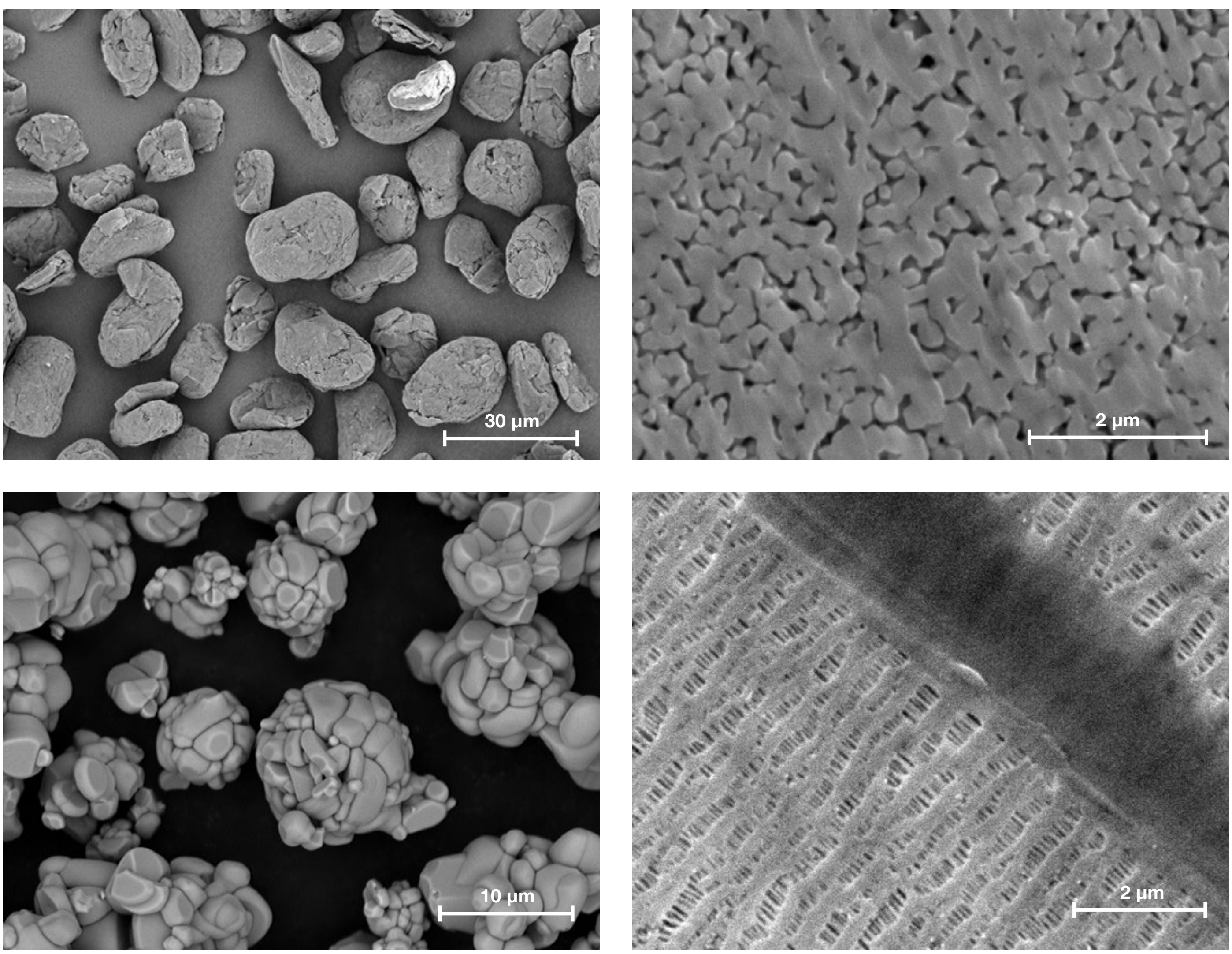
Imaging of battery cathode material with different detectors. Clockwise from bottom left: in-column SE, ETD, in-column BSE and mixed signal.



Low voltage imaging of battery separator (left) and anode (right).

Desktop SEM Imaging with the Phenom

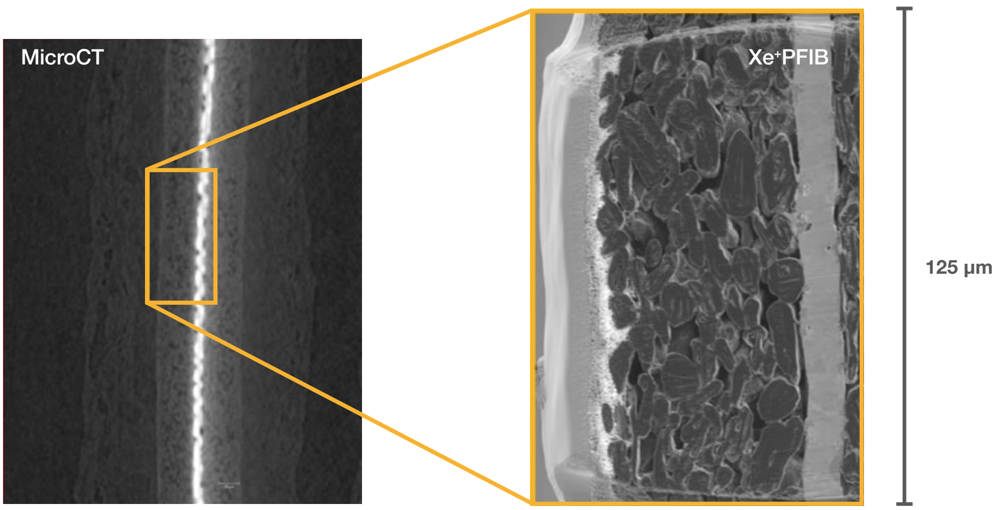
Fast and easy imaging of battery components, even in the glovebox.



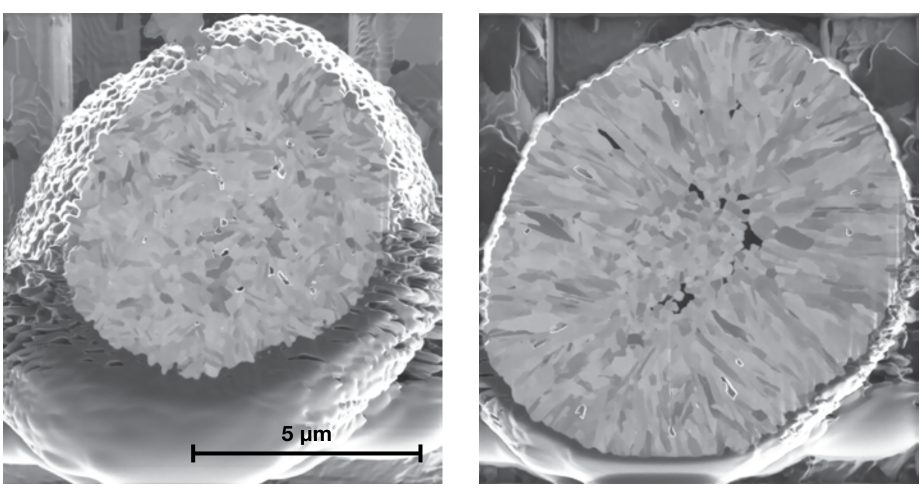
Clockwise from bottom left: battery cathode particles, battery anode particles, ion milled electrode and battery separator

Large Volume Correlative Imaging

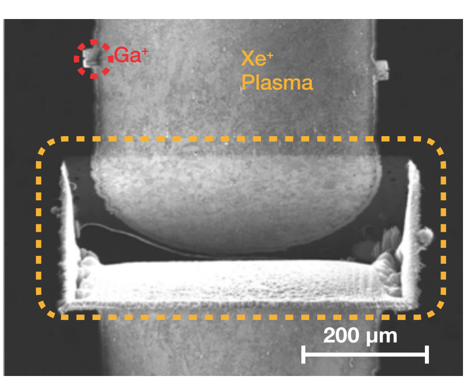
Plasma FIB-SEM images of representative volumes - bridging the gap between microCT and Ga-based FIB-SEM imaging.



3D Imaging of battery anode material in the Plasma FIB-SEM.



Section through an NMC particle with Ga FIB-SEM. Left: edge of particle with uniform grain size distribution Right: Center of particle with smaller grains in the middle.



Xe vs Ga FIB

Left image shows a comparison using the same milling time with Xe Plasma and Ga FIB:

Xe^+PFIB = **500µm wide, 500µm deep**
Ga^+ FIB = **30µm wide, 30µm deep**

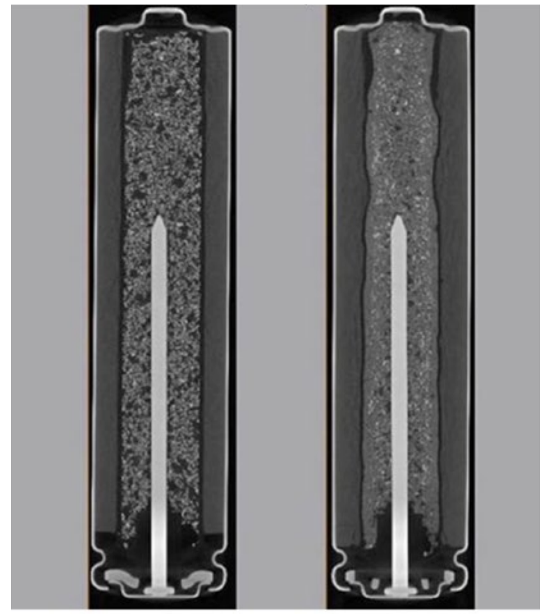
Heliscan microCT

Helical scanning for artifact free, low noise scanning

For samples with high aspect ratio such as AAA or 18650 batteries, helical scanning allows to scan the entire battery without the need to stitch fields as is common in conventional circular scanning.

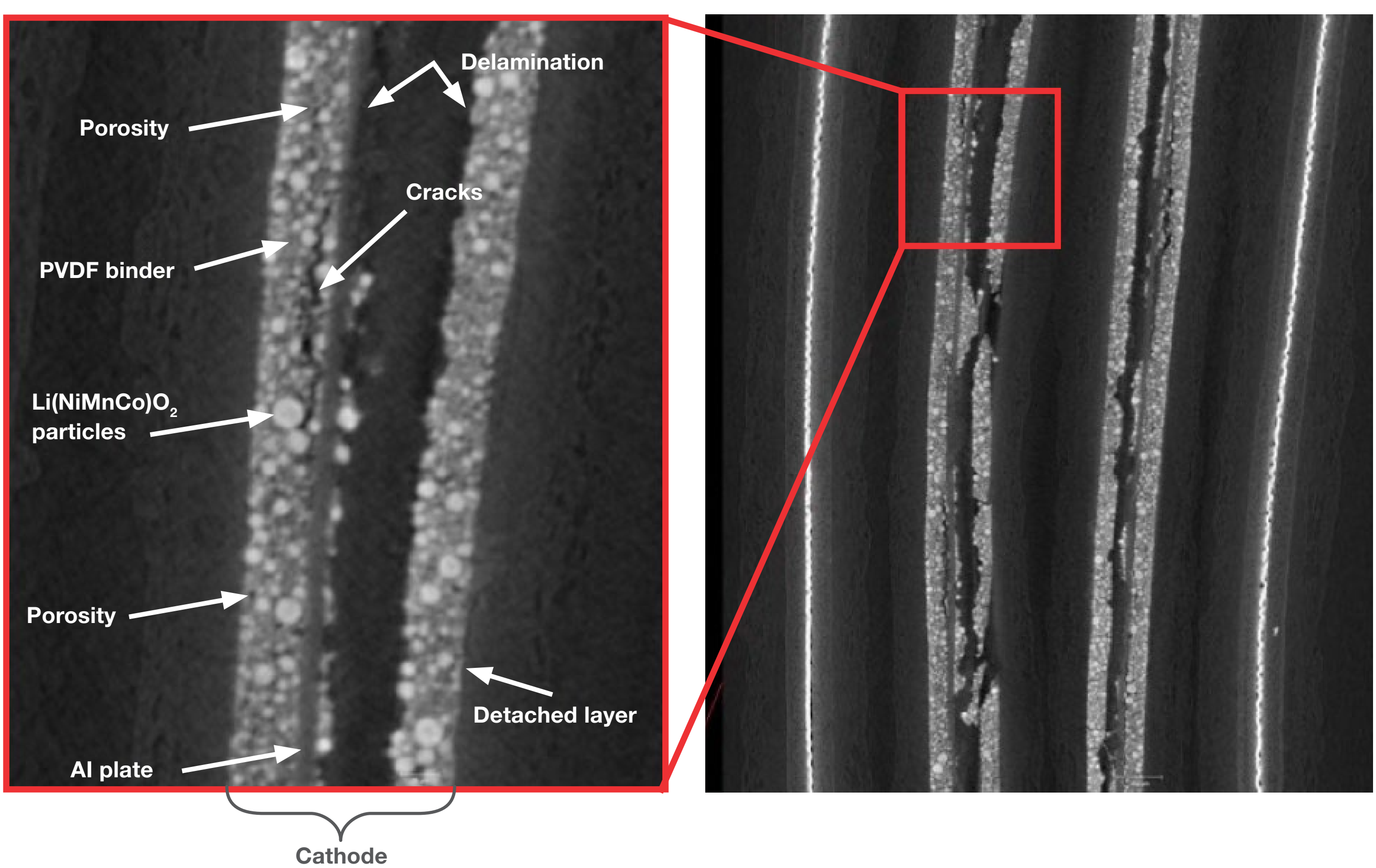
The high flux and flexible setup generates high quality images in considerably shorter time.

Besides the non-destructive imaging, the accurate 3D images produced by the HeliScan enables in-situ or ex-situ imaging of batteries to track changes in 3D morphology over multiple charging and discharging cycles.



new (left) used (right)

Heliscan images of AAA batteries



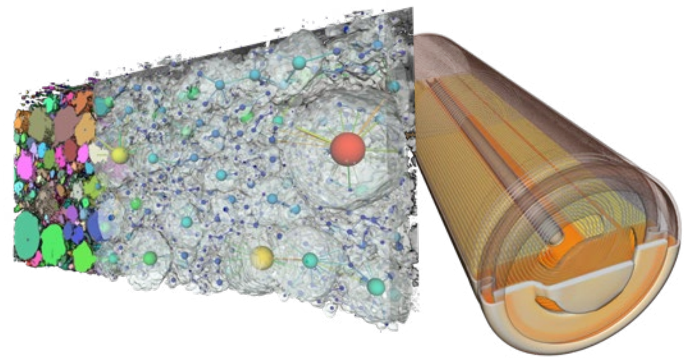
Battery cathode foil

Avizo Software

2D-5D materials characterization and quality control

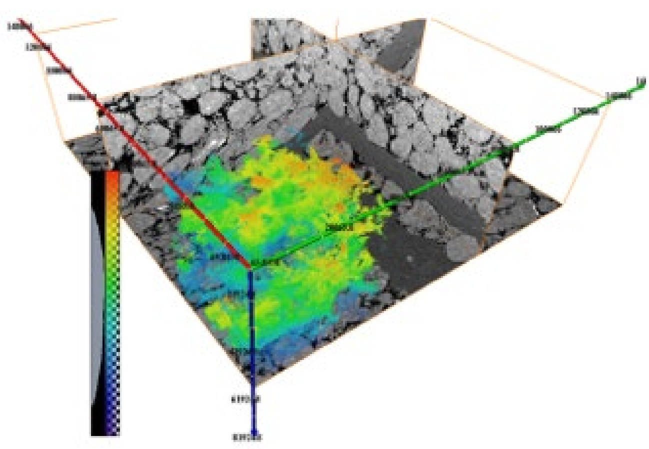
Thermo Scientific Avizo™ Software coupled with Thermo Scientific Electron Microscopes and microCT systems delivers the most comprehensive imaging to characterization and quality control workflow.

Thanks to advanced image processing and segmentation techniques, Avizo Software makes it possible to extract key quantitative parameters of the microstructure and macrostructure of the involved materials. At the macro level, Avizo Software can be used to assess the quality of the manufacturing process, looking into packaging, checking solder points, and detecting possible leakage or porosity and delamination. It can also examine the aging process, looking into foil, cathode and anode morphological changes or core leakage. At the microscopic level, Avizo Software allows for the estimation of the tortuosity and permeability of the porosity structure of electrode and separator; thus, effective transport parameters can be further used in the electrochemical performance simulation. Quantification of triple phase boundary (TPB), phase distribution and connectivity further allows for characterization of the cell's performance.

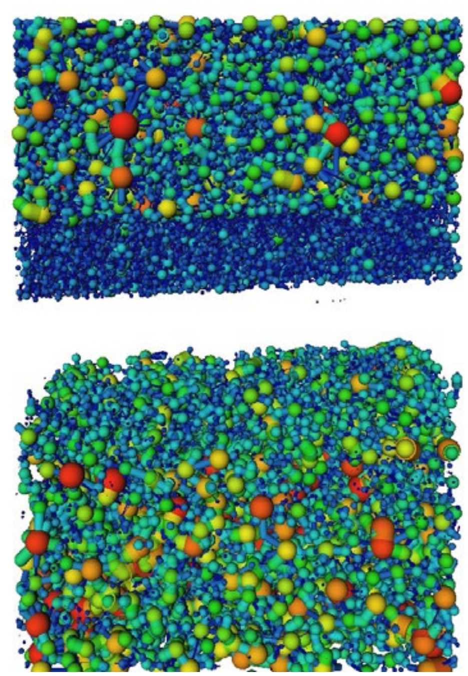


Battery Cathode. Active material connectivity analysis.
Data acquisition: Thermo Scientific Helios™ PFIB DualBeam™.

Li-ion cylindrical cell. Inspection of battery's structure.
Courtesy of Paul Shearing's group, University College London. Data acquisition: Thermo ScientificHeliScan™ microCT.



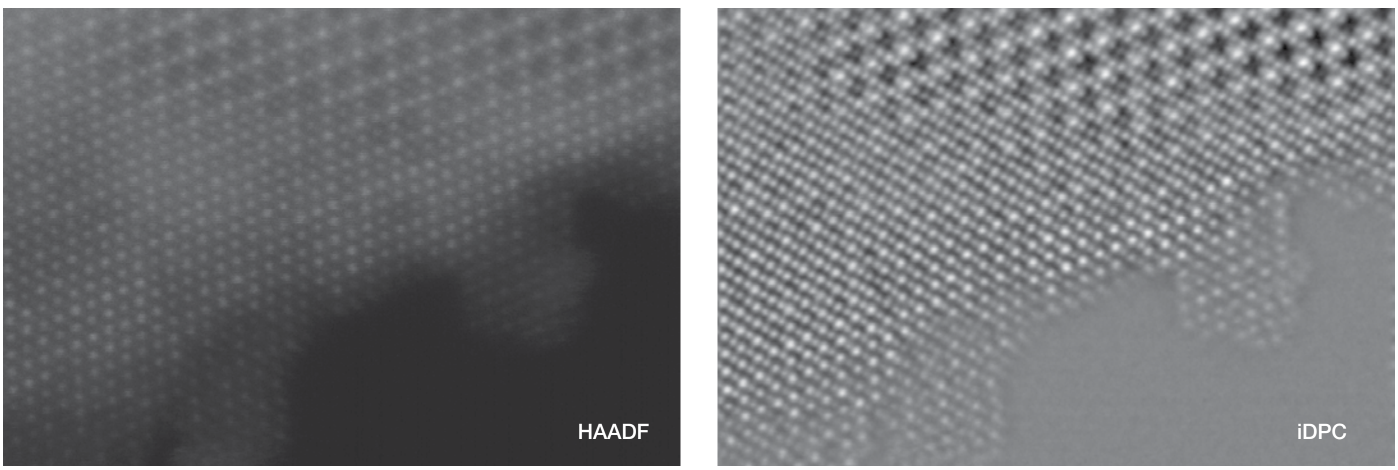
Permeability simulation and estimated pressure field. Data acquisition: Thermo Scientific Helios PFIB DualBeam.



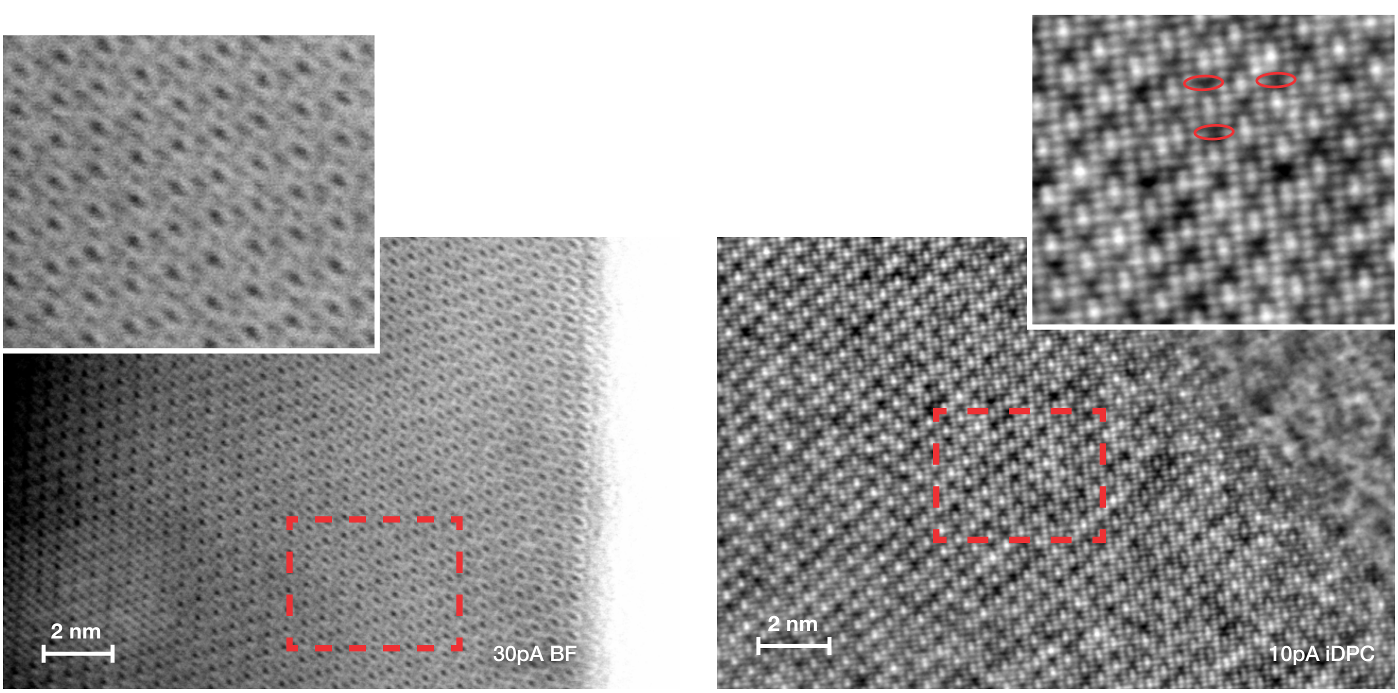
Segmentation from anode to cathode of a solid oxide fuel cell plasmaFIB dataset.

Direct Imaging of Lithium Atoms at the Atomic Scale in the TEM

Integrated Differential Phase Contrast (iDPC) STEM allows direct visualization of Lithium in the crystal structure of the electrode material.



iDPC allows to image both heavy and light atoms; making it ideal to elucidate crystal structures of battery electrodes. Furthermore, the iDPC technique needs less beam current than traditional imaging techniques. The top image shows simultaneous HAADF and iDPC; while the bottom images show the same sample in the same zone axis but at 30pA and 10pA respectively for brightfield and iDPC image.



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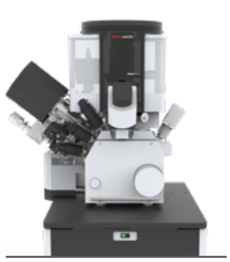

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Raman

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